Assessment Schedule – 2006

Physics: Demonstrate understanding of atoms, photons and nuclei (90522)

Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
1(a)	$\Delta m = 3 \times \text{p} + 3 \times \text{n} - \text{Li}$ $= 3 \times 1.67353 \times 10^{-27} + 3 \times 1.67492 \times 10^{-27}$ $- 9.98835 \times 10^{-27} = 5.700 \times 10^{-29}$ kg	[2]Correct working.		
1(b)	Total binding energy $E = \Delta mc^2$ $E = 5.700 \times 10^{-29} \times (3.00 \times 10^8)^2$ $= 5.13 \times 10^{-12}$ J Li has 6 nucleons so, per nucleon $\Rightarrow \frac{5.13 \times 10^{-12}}{6} = 8.55 \times 10^{-13}$ J	[2]Correct total binding energy.	[2]Correct answer.	
1(c)	A higher binding energy per nucleon indicates a more stable nucleus.	[1]Correct idea.		
1(d)	Mass of reactants = $3.34449 \times 10^{-27} + 5.00827 \times 10^{-27} = 8.35276 \times 10^{-27}$ kg Mass of products = $1.67492 \times 10^{-27} + 6.64648 \times 10^{-27} = 8.32140 \times 10^{-27}$ kg Mass deficit = $8.35276 \times 10^{-27} - 8.32140 \times 10^{-27} = 3.136 \times 10^{-29}$ kg $E = mc^2 = 3.136 \times 10^{-29} \times (3.00 \times 10^8)^2$ $= 2.82 \times 10^{-12}$ J		[2]Correct answer.	
1(e)	Fusion requires two nuclei to combine. For this to happen they have to overcome the net repulsion between two nuclei. It is only at very high temperatures that the nuclei have enough energy to do this.	[1]Recognition that: high temperature produces high energy for nuclei to collide / net repulsion between nuclei must be overcome during fusion.	[1]High speed gives the large amount of energy required to overcome repulsion.	
2(a)	$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 1.5236 \times 10^6$ $\Rightarrow \lambda = 6.563 \times 10^{-7}$ m	[2]Correct answer. [1]Answer given to 4 sf plus 4 answers given with a (correct) unit.		
2(b)	Light of this frequency is produced when an electron in the third energy level (second excited state) falls to the second energy level. The energy lost is then released as a photon of light, with energy $E = hf$. OR consistent with transition from 2(a).	[1]Recognition that: energy transition from 3rd to 2nd level is required / loss in energy during transition creates a photon.	[1]Correct energy transition linked to photon / specific frequency production.	

2(c)	Energy in an energy level is $E_n = \frac{-hcR}{n^2}$ Energy lost = $\frac{hcR}{1^2} - \frac{hcR}{7^2}$ $= 6.63 \times 10^{-34} \times 3.00 \times 10^8 \times 1.097 \times 10^7$ $\times (1 - \frac{1}{49}) = 2.13740 \times 10^{-18}$ J Energy 1st photon = $hf = \frac{hc}{\lambda}$ $= 6.63 \times 10^{-34} \times \frac{3.00 \times 10^8}{2.165 \times 10^{-6}}$ $= 9.18707 \times 10^{-20}$ J $\Rightarrow$ Energy 2nd photon $= 2.13740 \times 10^{-18}$ $- 9.18707 \times 10^{-20} = 2.0455 \times 10^{-18}$ J λ from $E = hf = \frac{hc}{\lambda}$ so $\lambda = \frac{hc}{E}$ $= 6.63 \times 10^{-34} \times \frac{3.00 \times 10^8}{2.0455 \times 10^{-18}}$ $= 9.7238 \times 10^{-8} = 9.72 \times 10^{-8}$ m OR $\frac{1}{2.165x10^{-6}} = 1.097x10^7\left(\frac{1}{s^2} - \frac{1}{7^2}\right)$ $s = 4$ $\frac{1}{\lambda} = 1.097x10^7\left(\frac{1}{1^2} - \frac{1}{4^2}\right)$ $\lambda = 9.7235x10^{-8}\,m$	[2]Correct wavelength consistent with incorrectly calculated energy of 2nd photon **OR** Intermediate energy level 4 **OR** Correct wavelength for incorrect intermediate energy level. **OR** Total energy change correct.	[2]Correct energy of 2nd photon.	[2]Correct answer.
2(d)	Some wavelengths are missing because the photons with those wavelengths must have been absorbed. This absorption must have occurred because there are atoms between the sun and the Earth that have electrons whose energy levels have transitions that correspond to the energy of the photons that are missing.	[1]Correct idea of absorption of light by electrons/ atoms/ elements.	[1]Recognition that specific wavelengths of light are absorbed by electrons in atoms/ absorbed for electron transition.	[1]Correct link to absorption of photons of specific wavelengths due to allowed electron transitions.
3(a)	Photoelectric effect	[1]Correct answer.		
3(b)	Photons of IR light have frequency / energy too low to release photoelectrons/below threshold frequency/ lower than work function.	[1]Correct answer.		
3(c)	Energy of photon must be 2.58×10^{-19} J $E = hf \Rightarrow f = \frac{2.58 \times 10^{-19}}{6.63 \times 10^{-34}}$ $= 3.8914 \times 10^{14} = 3.89 \times 10^{14}$ Hz	[2]Correct answer.		

3(d)	Each photon is able to release one electron. The frequency of the photons determines the energy of the electrons released. An electron needs a minimum amount of energy to be released and so below a threshold frequency no electrons are released. Above this frequency the energy of each electron is whatever is left after the release energy has been used. Therefore as the frequency is decreased the energy of the electrons released decreases. The number of electrons released does not change as the number of photons is the same, given that the intensity is the same. Below the threshold frequency no electrons are released.	[1]Decreasing frequency means decreasing electron energy / decreasing frequency does not change the number of electrons/ lower frequency below threshold frequency so no electrons.	[1]Link between decreasing frequency and decreasing energy is explained in terms of Ek= h$f - \phi$ / link between decreasing frequency and same number of electrons explained in terms of photon numbers.	[1]Explanation correctly links the observation of changes in electron energy and numbers as frequency decreases to photon nature of light and work function, including threshold frequency.
3(e)	$E_{\text{photon}} = \text{h}f$ and $\text{c} = f\lambda \Rightarrow E_{\text{photon}} = \dfrac{\text{hc}}{\lambda}$ $E_{\text{photon}} = \dfrac{6.63\times10^{-34}\times3.00\times10^{8}}{280\times10^{-9}}$ $= 7.104 \times 10^{-19}$ J $E_{\text{electron}} = 3.04 \times 10^{-19}$ J $E_{\text{photon}} = E_{\text{electron}} + E_{\text{work function}}$ $\Rightarrow E_{\phi} = 7.104 \times 10^{-19} - 3.04 \times 10^{-19}$ $= 4.064 \times 10^{-19}$ J $E_{\text{work function}} = E_{\text{photon}}(\text{min}) = \text{h} \times f_{\text{min}}$ $f_{\text{min}} = \dfrac{4.064\times10^{-19}}{6.63\times10^{-34}}$ $= 6.13 \times 10^{14}$ Hz		[2]Correct photon energy or correct answer consistent with either incorrectly calculated photon energy or incorrectly calculated work function energy.	[2]Correct answer.

Judgement Statement

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Criterion One

Achievement	Achievement with Merit	Achievement with Excellence
THREE opportunities answered at Achievement level or higher. $3 \times$ A1	FIVE opportunities answered with TWO at Merit level or higher. $2 \times$ M1 *plus* $3 \times$ A1	FIVE opportunities answered with ONE at Excellence level and at least TWO at Merit level or higher. $1 \times$ E1 *plus* $2 \times$ M1 *plus* $2 \times$ A1

Criterion Two

Achievement	Achievement with Merit	Achievement with Excellence
TWO opportunities answered at Achievement level or higher. $2 \times$ A2	THREE opportunities answered with ONE at Merit level or higher. $1 \times$ M2 *plus* $2 \times$ A2	FOUR opportunities answered with ONE at Excellence level and at least TWO at Merit level or higher. $1 \times$ E2 *plus* $1 \times$ M2 *plus* $2 \times$ A2